CHAPTER 2. PART 29
AIRWORTHINESS STANDARDS
TRANSPORT CATEGORY ROTORCRAFT

SUBPART G - OPERATING LIMITATIONS AND INFORMATION

OPERATING LIMITATIONS

AC 29.1501. § 29.1501 (Amendment 29-15) OPERATING LIMITATIONS - GENERAL.

This section simply requires specified operating limitations in addition to any other information necessary for the safe operation of the rotorcraft to be determined. Secondly, it requires that this pertinent information be made readily available to the crewmembers as required in the various sections of this subpart.

AC 29.1503. § 29.1503 AIRSPEED LIMITATIONS: GENERAL.

a. Explanation. This section requires that a safe operating speed range be established for all rotorcraft. If the safe operating speed range varies with operating conditions (rotor speed, power, etc.), ambient conditions (altitude and/or temperature), rotorcraft configuration (gross weight, center of gravity, and/or external equipment), or type of operation (in ground effect (IGE), instrument flight rules (IFR), etc.), airspeed limitations that correspond with the most critical combinations of these factors must be established.

b. Procedures.

(1) Airspeed Limitations. The airspeed limitations for each critical combination of factors are established by tests or analyses and verified by flight test. The following are airspeed limitations that are typically required depending on the particular rotorcraft design:

(i) V_{NE} (Power On). See paragraph AC 29.1505.

(ii) V_{NE} (One Engine Inoperative (OEI)). See paragraph AC 29.1505.

(iii) V_{NE} (Power Off). See paragraph AC 29.1505.

(iv) V_{LO} (Maximum Airspeed for Landing Gear Operation). Compliance with structural, handling qualities, and controllability requirements should be demonstrated at the airspeed limit.

(v) V_{LE} (Maximum Airspeed Landing Gear Extended). If this airspeed limit differs from the maximum gear operation speed, compliance with the applicable structural, handling qualities, and controllability requirements should be demonstrated.

(vi) Low Speed Flight Limitation. It is permissible for the applicant to establish a minimum airspeed operating limitation as a function of weight, altitude, and temperature as long as there is still a practical flight envelope.

(vii) V_{MINI} (Minimum IFR Speed). The minimum speed for which compliance with the IFR handling qualities requirements has been demonstrated should be established as a limit for IFR operations.

(viii) Maximum Sideward and Rearward Flight Speed. The maximum demonstrated sideward flight or crosswind hover and rearward flight or tailwind hover airspeeds should be provided in the RFM. If these maximum speeds resulted from a control margin limitation, they should be included in the airspeed limitations section of the RFM. If adequate control margin remained for the critical combination of rotorcraft configuration and ambient conditions, the maximum demonstrated sideward or rearward flight airspeeds should be included in either the performance section or the limitations section of the RFM as the applicant desires.

(ix) Maximum Airspeeds for Special Configurations or Special Equipment. Standard configuration airspeed limits frequently have to be reduced for specific changes or external modifications. The following are examples of special equipment or configurations that have required additional airspeed limitations:

(A) Doors open or doors off.

(B) External hoist/cargo hook (stowed).

(C) Fixed or emergency flotation gear.

(D) External avionics equipment (large antennas, wires, etc.)

(E) External fuel tanks.

(F) Skid pad or ski equipment modifications to standard skid type landing gear.

(x) Maximum Airspeeds after Failure of Required Equipment. Rotorcraft that require auxiliary equipment such as stability augmentation systems to comply with FAR requirements throughout the approved operating envelope frequently require airspeed limitations following failure of part or all of this system in order to comply after the failure. The following are examples of auxiliary equipment that have required maximum airspeed limitations after failure of all or part of the system:

(A) Stability Augmentation Systems (SAS).

(B) Automatic Flight Control Systems (AFCS).

(C) Fly-by-Wire Elevator Systems (FBW).

(D) Air Data Computer Systems (ADC).

(2) Groundspeed Limitations. Although not specifically required by this "airspeed limitations" regulation, it may be necessary to establish "groundspeed" limitations for wheel-gear-equipped rotorcraft. These limitations are required to show compliance with the ground-handling characteristic requirements, structural strength requirements, or the ground-loads requirements. However because of the operational similarity of groundspeed limits to airspeed limits, it is a common practice to include groundspeed limitations under the airspeed limitations heading in the flight manual. For this reason, groundspeed limitations are included in this paragraph of the AC. Groundspeed limitations should be established with adequate safety margins to account for the possible inaccuracies associated with the necessity for the pilot to estimate groundspeed from indicated airspeed and available wind speed and direction information during actual operations. The following are examples of groundspeed limitations that have been required during past type certification programs:

(i) Maximum Groundspeed for Takeoff or Landing. The maximum acceptable groundspeed that can safely be used for wheel gear equipped rotorcraft takeoff and landing maneuvers should be determined based on landing gear limitations or ground controllability limitations. This speed should be fast enough to account for landing touchdown speeds at the maximum approved density altitude for normal takeoff and landing.

(ii) Maximum Groundspeed for Brake Application. The maximum speed at which the wheel brakes may be applied without exceeding maximum brake energy capabilities should be determined for wheel gear equipped rotorcraft. This speed should be verified by test throughout the approved takeoff and landing envelope of the rotorcraft. The critical combination of gross weight and density altitude for brake energy considerations may be determined by analysis to minimize the required amount of testing. The maximum brake application groundspeed should be high enough to encompass brake application during landing at the maximum approved density altitude.

(iii) Other Groundspeed Limitations. For some rotorcraft designs with skid type landing gear, it may be necessary to establish a maximum landing touchdown speed for normal operations to comply with structural requirements. Optional equipment configurations such as float equipment, skis, etc., which are attached to conventional landing gear skids may require maximum landing groundspeed limits that are less than the limit for the basic rotorcraft.

AC 29.1505. § 29.1505 (Amendment 29-24) NEVER-EXCEED SPEED.

a. Explanation.

(1) General. This rule requires the never-exceed speed (V_{NE}) for both power-on and power-off flight to be established as operating limitations. The rule specifies how to establish and substantiate these limits.

(2) Power-on Limits.

(i) All Engines Operative (AEO).

(A) The all-engines-operating V_{NE} is established by design and substantiated by flight tests. The V_{NE} limits are the most conservative value that demonstrates compliance with the structural requirements (§ 29.309), the maneuverability and controllability requirements (§ 29.143), the stability requirements (§§ 29.173 and 29.175), or the vibration requirements (§ 29.251). The power-on V_{NE} will normally decrease as density altitude or weight increases. A variation in rotor speed may also require a variation in the V_{NE}. The regulation restricts the number of variables that are used to determine the V_{NE} at any given time so that a single pilot can readily ascertain the correct V_{NE} for his flight condition with a minimum of mental effort. Rotorcraft that are equipped with air data computers or other similar equipment are allowed to vary as many parameters as desired, if the final results are no more than two parameters that define the V_{NE} displayed to the pilot in an unambiguous manner. These rotorcraft must also have a method for determining V_{NE} that complies with the regulation in the event the air data computer system fails. This method is usually more conservative than the automatic system because of the limitation in the number of parameters that can be varied.

(B) To ensure compliance with the structural requirements (§ 29.309), vibration requirements (§ 29.251), and flutter requirements (§ 29.629), the all-engines-operating V_{NE} should be restricted so that the maximum demonstrated main rotor tip mach number will not be exceeded at 1.11 V_{NE} for any approved combination of altitude and ambient temperature. Previous rotorcraft cold weather tests have shown that the rotor system may exhibit several undesirable and possibly hazardous characteristics due to compressibility effects at high advancing blade tip mach numbers. As the center of pressure of the advancing rotor blade moves aft near the blade tip due to the formation of localized upper surface shock waves, rotor system loads may increase, the rotor system may exhibit an aerodynamic instability such as rotor weave, rotorcraft vibration may increase substantially, and rotorcraft static or dynamic stability may be adversely affected. Which, if any, of these adverse characteristics are exhibited at high rotor tip mach numbers is dependent on the design of each particular rotor system. FAA/AUTHORITY experience has shown some adverse characteristics exist for all the types of rotor systems (articulated, semirigid, rigid, etc.) and the various rotor blade designs evaluated at high advancing blade tip mach numbers during past certification programs. Therefore, it has been FAA/AUTHORITY policy to establish V_{NE} so that it is not more than 0.9 times the maximum speed substantiated for advancing blade tip mach number effects for the critical combination of altitude, approved power-on rotor speed, and ambient temperature conditions. This policy was incorporated as a specific regulatory requirement with Amendment 29-24 to § 29.1505. High main rotor tip mach

numbers obtained power off at higher than normal main rotor rotational speeds should not be used to establish the maximum power-on tip mach number V_{NE} limit. In addition, since the onset of adverse conditions associated with high tip mach numbers can occur with little or no warning and amplify very rapidly, no extrapolation of the maximum demonstrated main rotor tip mach number V_{NE} limitation should be allowed.

(C) A maximum speed for use of power in excess of maximum continuous power (MCP) should be established unless structural requirements have been substantiated for the use of takeoff power (TOP) at the maximum approved V_{NE} airspeed. TOP is intended for use during takeoff and climb for not more than 5 minutes at relatively low airspeeds. However, FAA/AUTHORITY experience has shown that pilots will not hesitate to use TOP at much higher than best-rate-of-climb airspeeds unless a specific limitation against TOP use above a specified airspeed is included in the RFM. Structural and fatigue substantiations have not normally included loads associated with the use of TOP at V_{NE}. Thus, a TOP airspeed limitation should be established from the structural substantiation data to preclude the accumulation of damaging rotor system and control mechanism loads through intentional use of the TOP rating at high airspeeds.

(ii) One Engine Inoperative (OEI). An OEI V_{NE} is generally established through flight test and is usually near the OEI V_H of the rotorcraft. It is the highest speed at which the failure of the remaining engine must be demonstrated. For rotorcraft with more than two engines, the appropriate designation would be "one-engine-operating" V_{NE} and would be that speed at which the last remaining engine could be failed with satisfactory handling qualities. It is possible that a rotorcraft with more than two engines could have different V_{NE}'s depending upon the number of engines still operating. It is recommended that the OEI V_{NE} not be significantly lower than the OEI best range airspeed. For the last remaining engine failure case, a multiengine rotorcraft may require an OEI V_{NE} if the handling qualities are not satisfactory, if the rotor speed decays below the power-off transient limits, or if any other unacceptable characteristic is found at speeds below the all-engine-operating V_{NE}.

(3) Power-off Limits.

(i) A power-off V_{NE} may be established either by design or flight test and should be substantiated by flight tests. A power-off V_{NE} that is less than the maximum power-on V_{NE} is generally required if the handling qualities or stability characteristics at high speed in autorotation are not acceptable. A limitation of the power-off V_{NE} may also be used if the rotorcraft has undesirable or objectionable flying qualities, such as large lateral-directional oscillations, at high autorotational airspeeds. The power-off V_{NE} must meet the same criteria for control margins as the power-on V_{NE}. The regulation requires that the power-off V_{NE} be no less than the speed midway between the power-on V_{NE} and the speed used to comply with the rate of climb requirements for the rotorcraft. When the regulation was written, rotorcraft V_{NE} speeds were significantly lower than those of recently certificated rotorcraft. The high V_{NE} speeds of current

rotorcraft result in relatively high values for the power-off V_{NE}. Speeds lower than that specified in the regulation have been found acceptable through a finding of equivalent safety if the selected power-off V_{NE} is equal to or greater than the power-off speed for best range. In any case, the power-off V_{NE} must be a high enough speed to be practical. A demonstration is required of the deceleration from the power-on V_{NE} for Category B rotorcraft, or OEI V_{NE} for transport rotorcraft with Category A engine isolation, to the power-off V_{NE}. The transition must be made in a controlled manner with normal pilot reaction and skill.

(ii) In addition to the minimum speed requirements for power-off V_{NE}, the rule restricts the manner in which power-off V_{NE} can be specified. Power-off V_{NE} may be a constant airspeed which is less than power-on V_{NE} for all approved ambient condition/gross weight combinations; a series of airspeeds varying with altitude, temperature or gross weight that is always a constant amount less than the power-on V_{NE} for the same ambient condition/gross weight combination; or some combination of a constant airspeed for a portion of the approved altitude range and a constant amount less than power-on V_{NE} for the remainder of the approved altitude range.

b. Procedures. The tests to substantiate the different V_{NE} speeds are ordinarily conducted during the flight characteristics flight tests. The flight test procedures are discussed for the various limiting areas in earlier paragraphs of this AC. The controllability test techniques are covered in paragraph AC 29.143, static stability test techniques in paragraph AC 29.175, and the vibration test techniques in paragraph AC 29.251.

AC 29.1509. § 29.1509 ROTOR SPEED.

a. Explanation.

(1) General. This rule requires minimum and maximum power-off rotor speeds to be established as operating limitations. It also specifies the appropriate margins below and above these limits which must be substantiated structurally and by flight tests. In addition to addressing power-off limits, the rule requires that minimum power-on RPM be established as an operating limit, and it specifies conditions, by reference, for establishing a minimum appropriate power-on speed.

(2) Power-off Limits. The power-off or autorotational RPM limits are established by design and substantiated by structural testing. Limits are confirmed during flight testing. Critical components must be designed for RPM values at least 5 percent above and below the maximum and minimum approved RPM values respectively. This 5 percent conservative speed requirement is in addition to the other structural safety factors built into the design requirements. A transient limit lower than the minimum in-flight RPM (power-off) will be defined to cover the final phase of a total power-off landing. Maximum weight is ordinarily critical for both tests. At low RPM, high coning angles can produce high stress levels in blade bending. Large flapping angles or controllability problems may also develop. At high RPM values, centrifugal

forces on the blades are at their highest and stress levels on rotating components such as blade grips may be critical. If a particular model has a very large weight spread between minimum and maximum gross weights, the applicant may elect to specify two ranges of power-off RPM dependent upon weight. This may be needed to assure adequate power-off rotor RPM with collective full down without requiring the very low power-off rotor speeds at maximum weight, a condition which would be inappropriate for operation of the rotorcraft in service. Transient power-off RPM ranges may also be approved if needed for engine failure conditions; however, these transients must also be substantiated structurally and in flight.

(3) Power-on Limits. The minimum power-on rotor speed must be established so that it is no less than the minimum rotor speed which has been established structurally. The minimum power-on speed also cannot be less than those values achieved during any of the critical maneuvers during flight test substantiation of the rotorcraft. A 5 percent margin between the substantiated value and the limit value is not required as in the power-off case. This rule also makes reference to § 29.33(a)(1) and (c)(1) for establishing the minimum power-on value. The reference to paragraph (a)(1) is intended to assure that the minimum power-on RPM value is low enough to accommodate the RPM values which will occur as a result of power changes and flight maneuvers expected in service. The reference to (c)(1) establishes the requirement that the minimum power-on RPM can be no lower than the minimum power-off RPM. For single engine rotorcraft, this assures some transition capability to power-off flight conditions when an engine fails. For multiengine rotorcraft, it allows transition from power-on to power-off conditions as when transitioning from a cruise condition to a power-off descent. Although the maximum power-on value is not specifically referred to in this section, it must be established as a limitation per § 29.309. Since the considerations regarding smooth transition from power-on to power-off flight [reference § 29.141(b)] are similar to the minimum power-on condition described above, it may be inferred that maximum power-on RPM may not be greater than maximum power-off RPM.

(4) Transient Limits. Transient limits must be substantiated and approved in a similar manner. Transient limits may be outside of the steady state “red-line” limits.

b. Procedures.

(1) Tests for substantiation of stress and vibration at the 5 percent underspeed and overspeed conditions in autorotation are ordinarily conducted as a part of the flight strain survey. For purposes of finding compliance with this rule, it is suggested that as a minimum, FAA/AUTHORITY certification personnel witness applicable portions of the test program and monitor telemetry or flight recorded data, as necessary, to verify compliance with this rule. Tests at maximum weight and at a relatively light weight condition are normally sufficient. Tests must be conducted at speeds up to V_{NE} (power-off) at 105 percent of maximum RPM and 95 percent of minimum RPM. It is also appropriate to investigate speeds to 1.1 V_{NE} (power-off) at maximum and minimum power-off RPM values. The normal low pitch stop may need to be downrigged in order

to achieve the high RPM values at high speed. This feature should be coordinated with the manufacturer prior to the flight strain survey to assure necessary conditions are achieved. It may be difficult to obtain minimum power-off RPM prior to encountering retreating blade stall at combinations of high weight, high collective pitch, low rotor speed, and high forward speed. In this case V_{NE} (power-off) can either be decreased in accordance with § 29.1505(c) or the low RPM range can be evaluated in a transient manner during engine failure testing at high speed. Any condition in which blade stall is suspected should, of course, be investigated with a great deal of caution and build-up testing is recommended. The transient low RPM limit for power-off landings may be tested only during actual power-off landings. In that case, the 5 percent margin is not required.

(2) Testing for suitable minimum and maximum power-on RPM values may be conducted during the designated FAA/AUTHORITY flight test program. The combined engine and governor response must allow accomplishment of all appropriate flight maneuvers without exceeding minimum or maximum power-on rotor limits. As in the power-off case, appropriate transient ranges and limits may be approved when properly substantiated. Transient ranges should be evaluated using similar methods and techniques to those described above. Power-on RPM determination must include not only rotor system considerations but engine and drive system characteristics as well. It is important to remember that all power-on ranges must be eligible under the Part 33 engine approval and that the power-off range must include adequate margins from potentially hazardous drive system phenomena, such as drive shaft whirl modes.

AC 29.1517. §29.1517 (Amendment 29-21) LIMITING HEIGHT-SPEED ENVELOPE.

a. Explanation.

(1) This section requires that the height-velocity (HV) envelope developed in compliance with § 29.79 of the performance requirements be established as an operating limitation for Category A rotorcraft.

(2) For rotorcraft with FAR Part 29 and CAR Part 7 certification bases prior to Amendment 29-21, this section requires that the HV envelope be established as an operating limitation for Category B rotorcraft as well as Category A. The rule was revised by Amendment 29-21 to allow the HV envelope to be provided as performance information rather than as a limitation for rotorcraft meeting the revised § 29.1 Category B requirements. In addition, supplemental type certificates have been approved which allow Category B rotorcraft meeting the revised § 29.1(f) requirements to move the HV envelope from the limitations section to the performance section of the Rotorcraft Flight Manual (RFM). (See paragraph AC 29.1583.)

b. Procedures. The limiting height-speed envelope developed in accordance with § 29.79 should be established as an operating limitation or as performance information to be included in the RFM in accordance with §§ 29.1583(f) and 29.1587(b)(6). (See paragraphs AC 29.79, AC 29.1583, and AC 29.1587 for additional information.)

AC 29.1519. § 29.1519 WEIGHT AND CENTER OF GRAVITY.

a. Explanation. This rule requires that weight and center of gravity (CG) combinations which are substantiated structurally and also found satisfactory during flight tests (per §§ 29.25 and 29.27) must be established as operating limits. A related portion in § 29.1583(c) further requires that weight and CG limitations be entered in the Rotorcraft Flight Manual Limitations Section. Both maximum and minimum weight must be established as operating limitations along with the corresponding longitudinal and lateral centers of gravity for each condition. Weight and CG limits are discussed in more detail in paragraphs AC 29.25 and AC 29.27.

b. Procedures.

(1) The results of shifts in center of gravity with fuel burn should be evaluated. If it is possible to take off within the approved loading envelope and subsequently burn fuel to a condition which is significantly beyond the approved weight/CG envelope, then there should be appropriate instructions in the loading and/or operating procedures of the RFM to avoid this condition.

(2) Typical loading conditions should not result in weight/CG combinations outside of approved limits. A minimum of two loadings, appropriate to the rotorcraft configuration, should be evaluated. These should include critical combinations of maximum/minimum variables for fuel, passengers, and crew. If this results in loading outside approved limits, special interior placarding or cautionary information should be provided in appropriate sections of the Rotorcraft Flight Manual.

AC 29.1521. § 29.1521 (Amendment 29-34) POWERPLANT LIMITATIONS.

a. Explanation.

(1) This rule requires that the various parameters and operating conditions listed under each type of operation be evaluated and established as operating limitations. The procedures for establishing and verifying each powerplant limitation are discussed in the powerplant section of this AC. This rule requires that powerplant limitations be established for four specific types of operation or power ratings: takeoff, continuous, 2 1/2-minute, and 30-minute. Additional limitations are required to account for engine and transmission cooling and minimum required fuel grade. The 2 1/2-minute and 30-minute limitations are optional requirements intended for use only on multiengine rotorcraft after failure of one engine. These limits are generally referred to as one-engine-inoperative (OEI) limitations.

(2) It is important to differentiate between the rotorcraft powerplant limitations and the engine limitations as established under Part 33. For some parameters, these two limits may be identical, but frequently the engines will be capable of exceeding the maximum limitations substantiated for the combined powerplant installation. Limitations

established according to this rule may not exceed the engine limitations established in accordance with Part 33 but may be less than the Part 33 limits as desired by the applicant.

b. Procedures.

(1) Determine the limiting parameters for each required power rating according to the requirements of Part 29, Subpart E, Powerplant. (See applicable paragraphs of this AC for detailed procedures.)

(2) Provide the limitations established according to this rule to the rotorcraft crew through placards in accordance with § 29.1541, instrument markings in accordance with § 29.1549, and in the Rotorcraft Flight Manual Limitations Section in accordance with § 29.1583(b). (See paragraphs AC 29.1543 and AC 29.1583.)

AC 29.1521A. § 29.1521 (Amendment 29-26) POWERPLANT LIMITATIONS.

a. Explanation. Amendment 29-26 revises §§ 29.1521(f) and (g) and adds a new § 29.1521(h). The changes to §§ 29.1521(f) and (g) introduce the term “OEI” to emphasize and clarify the limitations on the use of the 2 ½-minute and 30-minute power ratings. This change added the introductory phrase “unless otherwise authorized.” In order to authorize use of these ratings, additional qualification tests or other adequate safety measures have been instituted. Both §§ 29.1521(f) and (g) have been reworded to set forth specific limitations on the use of these ratings. These changes were made to clarify the eligibility of these ratings. The new § 29.1521(h) establishes and defines a new continuous OEI power rating using terminology similar to that developed for the 2 ½-minute and 30-minute power ratings. This change ensures proper recognition in the powerplant limitations listing required by § 29.1583.

b. Procedures. All of the policy material pertaining to this section remains in effect. Additionally, the following procedures should be considered:

(1) Sections 29.1521(f) through (h) require limitations for OEI operation for multi-turbine engine powered rotorcraft. The same parameters required for the takeoff and continuous ratings should be established as limitations for each approved OEI rating (i.e., maximum rotational speed, time, gas temperature, and torque). Section 29.923 includes requirements for qualification of the rotor drive system for 2 ½-minute, 30-minute, and continuous OEI powers. Section 29.1501(a) requires that information necessary for safe operation should be established as limitations. Thus the establishment of OEI powerplant limitations is required even though not specifically addressed in § 29.1521.

(2) It is important to differentiate between the rotorcraft powerplant limitations and the engine limitations as established under Part 33. For some parameters, these two limits may be identical, but frequently, the engines will be capable of exceeding the maximum limitations substantiated for the combined powerplant installation. Limitations

established according to this rule may not exceed the engine limitations established in accordance with Part 33 but may be less than the Part 33 limits as desired by the applicant.

AC 29.1521B. § 29.1521 (Amendment 29-34) POWERPLANT LIMITATIONS.

a. Explanation. Amendment 29-34 adds §§ 29.1521(i) and (j). The new §§ 29.1521(i) and (j) introduce the 30-second and 2-minute OEI power rating limitations, respectively. These paragraphs define the limitations on the use of the 30-second and 2-minute power ratings using terminology similar to that developed for the 2 ½-minute and 30-minute power ratings. Additionally, these paragraphs require the ability to detect any damage which occurs due to the use of either 30-second or 2-minute OEI limits and requires that the procedures to inspect for such damage be provided in the instructions for continued airworthiness for either the engine and/or the airframe.

b. Procedures. All of the policy material pertaining to this section remains in effect. Additionally, the following procedures should be considered:

Sections 29.1521(i) and (j) require limitations for 30-second/2-minute OEI operation for multi-turbine engine powered rotorcraft. The same parameters required for the takeoff and continuous ratings should be established as limitations for each approved OEI rating (i.e., maximum rotational speed, time, gas temperature, and torque). These new ratings can only be approved as a rating in conjunction with the other. That is, a rotorcraft with a 30-second OEI rating must also have a 2-minute OEI rating and vice-versa. The 30-second and 2-minute OEI ratings are also limited to use for continued operation of the remaining engine(s) upon failure or precautionary shutdown of an engine. Upon the use of 30-second or 2-minute OEI, an inspection for damage to the airframe and/or engine should be conducted. The inspection should be accomplished per the procedures furnished by the airframe and engine manufacturers, and any damage occurring due to the use of these new ratings should be detected using these inspection procedures. Section 29.923 includes requirements for qualification of the rotor drive system for 30-second and 2-minute OEI powers. Section 29.1501(a) requires that information necessary for safe operation should be established as limitations. The limitation information provided in this paragraph should be provided in the flight manual. This includes the requirement for an inspection prior to further flight after the use of either 30-second or 2-minute OEI.

AC 29.1522. § 29.1522 (Amendment 29-17) AUXILIARY POWER UNIT LIMITATIONS.

a. Explanation.

(1) Any APU installed in a rotorcraft will have operating limitations which have been developed by design and testing. These APU operating limitations become part of the operating limitations for the rotorcraft.

(2) TSO-C77 establishes the minimum performance standards and limitations which gas turbine APU's should meet in order to be identified with the TSO marking.

b. Procedure.

(1) Limitations for APU's which meet the requirements of TSO-C77 will be contained in the APU model specification and in one or more manuals containing instructions for the installation, operation, servicing, maintenance, repair and overhaul of the APU. Data from these documents which are required by the TSO, should be included in the rotorcraft flight manual (RFM) and in maintenance manuals, as appropriate.

(2) APU's which do not meet the requirements of TSO-C77 should have the design and operating limitations defined and included in the operating limitations section of appropriate rotorcraft manuals. TSO-C77 can be used as a guide to identify and develop the detailed data which will be included in the rotorcraft flight and maintenance manuals.

AC 29.1523. § 29.1523 MINIMUM FLIGHTCREW.

a. Explanation.

(1) This rule requires that the minimum crew necessary to show compliance with the requirements of Part 29 or for safe operation of the rotorcraft be established as an operating limitation.

(2) The determination of minimum crew requirements is typically based on a subjective pilot assessment of the crew requirements for safe operation of each rotorcraft design. Certain regulations, such as the requirements for instrument flight rules (IFR), have specific quantitative differences between single-pilot and two-pilot requirements. However, most often the minimum crew requirement will be based on more subjective considerations such as location of necessary controls, pilot workload to accomplish required tasks, type of operation, and overall complexity of the rotorcraft design.

(3) Minimum crew requirements for the same type design may vary with the kind of operation. Many rotorcraft have been approved for a single-pilot crew for visual flight rules (VFR) operations but require a two-pilot crew for IFR operations. Other kinds of operations that may require more than one crewmember to meet type certification requirements are night operations, operations into known icing conditions, operations in falling and blowing snow, extended overwater operations, and external load operations.

(4) It is important to distinguish between the minimum crew requirements for compliance with Part 29 type certification regulations and the minimum crew

requirements of the various operating regulations (Parts 61, 91, 121, 133, 135, and 137). A rotorcraft may be type certified for a minimum crew of one and still be required to have a crew of two or more by the operating regulations for certain types of operation or by the workload associated with an operating environment. Therefore, an applicant should carefully consider the possible operational uses of any rotorcraft design and become familiar with the applicable operating regulations as well as the type certification requirements early in the design process.

(5) Although the rotorcraft configuration is typically certified with the pilot-in-command station in the right seat, the left seat may be used for the pilot-in-command if, in addition to the flight controls required to control the rotorcraft, the following are included for the pilot: throttle control including ability to shut down all engines, airspeed indication, altitude indication, rotor and engine RPM, and engine torque and exhaust gas temperature. The authority should evaluate a change to the pilot-in-command station.

(6) The applicant is encouraged to contact the responsible type certification office as early in the design phase as possible to initiate the qualitative assessment process. Cockpit layout drawings, instrument panel mockups, and full-scale cockpit mockups can be used to determine if required controls are accessible and to begin the pilot workload assessment for certain operations.

b. Procedures.

(1) General.

(i) A systematic evaluation and test plan is required for any new or modified rotorcraft. The methods for showing compliance should emphasize the use of acceptable analytical, simulation, and flight test techniques. The crew complement should be studied through a logical process of estimating, measuring, and then demonstrating the workload imposed by a particular cockpit design. When the minimum crew requirements have been determined, they should be included in the limitations section of the Rotorcraft Flight Manual in accordance with § 29.1583(d).

(ii) Appropriate analysis should be conducted by the applicant early in the design process. The specific method(s) of analysis should be selected on the basis of its predictive validity, sensitivity, reliability, applicability to the particular cockpit configuration, and availability of a suitable reference for comparison.

(2) Analytical Approach.

(i) One analytical approach defines workload as a percentage of the time available to perform tasks (Time Line Analysis). This process may be applied to an appropriate set of flight segments in which operationally important time constraints can be identified. This method is useful for evaluation of cockpit changes relating to overt pilot work such as control movements and data inputs. The generally accepted practice

involves careful selection of the limited set of flight scenarios and time segments that represent the range of operational requirements (including the range of normal and non normal procedures.) Time line analysis yields useful data when tasks must be performed within operationally significant time constraints. The adequacy of this method is very much dependent on an accurate determination of the time available. Absolute standards are not available for interpretation of obtained time required scores, but such records can be used to identify high or simultaneous workload demands for later testing in a simulator or aircraft, and comparisons can be made with overt workload demands in proven aircraft. However, the impact of cockpit changes on planning and decisionmaking is difficult to quantify by this method.

(ii) The most frequently used basis for deciding that a new design is acceptable is a comparison of a new design with previous designs proven in operational service. By making specific evaluations using the acceptable human factors techniques, and comparing new designs to a known baseline, it is possible to proceed with confidence that the changes incorporated in the new designs accomplish the intended result. When the new cockpit is considered, certain components may be proposed as replacements for conventional items, and some degree of rearrangement may be contemplated. New avionics systems may need to be fitted into existing panels, and newly automated systems may replace current indicators and controls. As a result of this evolutionary characteristic of the cockpit design process, there is frequently a reference cockpit design, which is usually a conventional aircraft that has been through the test of operational usage. If the new design represents an evolution, improvement attempt, or other deviation from this reference cockpit, the potential exists to make direct comparisons. Service experience should be researched to assure that any existing problems are understood and not perpetuated.

(iii) If preliminary analysis by the certification team identify potential problem areas, these areas should receive more extensive evaluation and data collection in order to verify compliance with § 29.1523. These concerns should be adequately addressed in the manufacturer’s demonstration plan when submitted to the FAA/AUTHORITY**.**

(iv) If the new design represents a significant change in level of automation or pilot duties, analytic comparison to a reference design may have lessened value. Without a firm data base on the time required to accomplish both normally required and contingency duties, more complete and realistic simulation and flight testing will be required.

(3) Testing.

(i) In the case of the minimum crew determination, the final decision is reserved until the rotorcraft has been flown by experienced flight test pilots trained and current in the aircraft. More assurance is derived from actual flight tests than from earlier simulator tests or other synthetic or computer model procedures.

(ii) The test program should address the workload functions and factors listed below. For example, an evaluation of communications workload should include the basic workload required to properly operate the aircraft in the environment for which approval is sought. The goal is to evaluate workload with the proposed crew complement during realistic operating conditions, including representative air traffic and weather.

(A) Basic workload functions. The following basic workload functions are considered:

(1) Flight path control.

(2) Collision avoidance.

(3) Navigation.

(4) Communications.

(5) Operation and monitoring of aircraft engines and systems.

(6) Command decisions.

(B) Workload factors. The following workload factors are considered significant when analyzing and demonstrating workload for minimum flight crew determination:

(1) The accessibility, ease, and simplicity of operation of all necessary flight, power, and equipment controls, including emergency fuel shutoff valves, electrical controls, electronic controls, and engine controls.

(2) The accessibility and conspicuity of all necessary instruments and failure warning devices such as fire warning, electrical system malfunction, and other failure or caution indicators. The extent to which such instruments or devices direct the proper corrective action is also considered.

(3) The number, urgency, and complexity of operating procedures with particular consideration given to the specific fuel management schedule imposed by center of gravity, structural or other considerations of an airworthiness nature, and to the ability of each engine to operate at all times from a single tank or source which is automatically replenished if fuel is also stored in other tanks.

(4) The degree and duration of concentrated mental and physical effort involved in normal operation and in diagnosing and coping with malfunctions and emergencies.

(5) The extent of required monitoring of the fuel, hydraulic, electrical, electronic, deicing, and other systems while en route.

(6) The actions requiring a crewmember to be unavailable at his assigned duty station, including: observation of systems, emergency operation of any control, and emergencies in any compartment.

(7) The degree of automation provided in the aircraft systems to afford (after failures or malfunctions) automatic crossover or isolation of difficulties to minimize the need for any flight crew action to guard against loss of hydraulic or electric power to flight controls or to other essential systems.

(8) The communications and navigation workload.

(9) The possibility of increased workload associated with any emergency that may lead to other emergencies.

AC 29.1525. § 29.1525 (Amendment 29-24) KINDS OF OPERATION.

This rule states that the kinds of operation to which the rotorcraft is limited are established by demonstrated compliance with applicable certification requirements (primarily flight) and the equipment requirements established for that kind of operation. The basic flight characteristics requirements of Part 29 are suitable for day VFR approval. Additional night considerations appear in § 29.141(c) and in the operating rules. IFR requirements are addressed in § 29.141(c) and Appendix B to Part 29. Additional IFR equipment requirements are contained in the operating rules. Icing certification criteria are contained in paragraph AC 29.877. External load requirements for certification may be found in §§ 29.25(c) and 29.865(c) in addition to Part 133. Related § 29.1525(d) further requires that the approved kinds of operation must be listed in the operating limitations section of the Rotorcraft Flight Manual. The equipment that is necessary for a specific kind of operation other than basic day VFR operation should also be listed in the limitations section of the RFM.

AC 29.1527. § 29.1527 (Amendment 29-15) MAXIMUM OPERATING ALTITUDE.

a. Explanation. This rule requires that the maximum altitude for operation of the rotorcraft must be established as an operating limitation. The rule is intended to establish en route altitude as an operating limit. The requirements for maximum takeoff and landing altitude are contained in other portions of the rule. (See discussion in paragraph AC 29.151a(2)(ii).) The en route limit may be established by any of the preceding subparts of the rule involving flight, structural, powerplant, equipment or related functional requirements of those subparts. Maximum operating altitude is ordinarily specified initially by the manufacturer and substantiated throughout the type certification program by each engineering discipline. Maximum operating altitude must be established in terms of pressure altitude unless the pilot is provided with some equally functional means of observing specified altitude limits (e.g., a density altitude

indicator if maximum altitude is specified in terms of density altitude). A related requirement in § 29.1583 specifies that maximum operating altitude must be established as an operating limitation in the Rotorcraft Flight Manual and further that any limiting factors must be identified and explained.

b. Procedures. Each FAA/AUTHORITY engineering discipline must assure that data and testing are adequate to properly substantiate and qualify all critical components to the maximum operating altitude of the rotorcraft. The design or maximum substantiated altitude should be specified in the Type Inspection Authorization. The flight test program must include at least one test flight to the maximum approved altitude and this flight must include functional testing of all critical aircraft components. Due to specific requirements in § 29.21(b), no extrapolation of these results is allowed.

AC 29.1529. § 29.1529 (Amendment 29-20) INSTRUCTIONS FOR CONTINUED AIRWORTHINESS (MAINTENANCE MANUAL).

a. Explanation. The FAA/AUTHORITY has long recognized the necessity to have a maintenance manual for rotorcraft due to the unique and generally complicated and critical design features.

(1) Airworthiness Limitations Section.

(i) Amendment 29-4, October 1968, established the requirement for a separate and specific airworthiness limitations section. Section 43.15 was already in place. New § 43.16 was added to the maintenance rules, and § 91.163(c) was added to the operating rules to require compliance with this section of the maintenance manual.

(ii) Amendment 29-20, October 1980, revised the rule and added Appendix A containing requirements for preparation of instructions for continued airworthiness, including the airworthiness limitations section. Instructions for continued airworthiness replaced “rotorcraft maintenance manual” in the standard. The maintenance rules, §§ 43.15 and 43.16, and § 91.163(c) of the operating rules also refer to, or require, compliance with certain parts of the instructions for continued airworthiness. The airworthiness limitations were intended to define the limits of the type certification approval of the fatigue characteristics of “critical flight structure.”

(2) Rotorcraft type designs are unique in comparison to airplane designs in that transmissions and rotors have critical components that may be adversely affected by operating conditions and time in service. The FAA/AUTHORITY-approved airworthiness limitations section may include such items as gear sets, bearings, etc., of the rotorcraft type design if a finite life was established during the type certification program and if the FAA/AUTHORITY determined that mandatory inspections and/or replacement of the component (part) was necessary to maintain airworthiness of the rotorcraft. For example, a drive spline, gear, or bearing was serviceable after

concluding the ground endurance test and/or FAA/AUTHORITY flight test program. However, an FAA/AUTHORITY-mandated inspection or replacement of the component was considered essential for airworthiness of the rotorcraft type design and necessary for type certification. Time between overhaul (TBO) of components is not part of the airworthiness limitations. If an inspection or replacement of a part in an assembly is required, the inspection interval or replacement time and the part number should be included in the limitations. The inspection interval or replacement time may or may not coincide with the recommended overhaul interval of the assembly. (See the comments for Proposal 8-25, § XX.4 in the preamble of Amendment 29-20 (45 FR 60154, September 11, 1980). Note that parts considered unserviceable at the conclusion of the ground endurance test of § 29.923 are not acceptable for type certification.

(3) Certain components must be identified by part number (or equivalent) and serial number (or equivalent). Section 29.1529(a)(1) and (2) of Amendment 29-4 and § 45.14 of Amendment 45-12 list the requirements. The part number of parts and/or components requiring inspections and/or replacement as a result of § 29.571 or other standards must be listed in the airworthiness limitations section of the manual or another separate, segregated section of the manual appropriate to the rules.

(4) Control rigging procedures are included in the manuals. Since rotorcraft are generally difficult to rig properly, it is important that these procedures be correct and complete.

b. Procedures.

(1) General.

(i) The rule of Amendment 29-4 and its predecessor stated that the maintenance manual must contain all information that the applicant considers essential for proper maintenance. Amendment 29-4 also added the requirement for an airworthiness limitations section. Amendment 29-20 revised § 29.1529 and added Appendix A that now contains the requirements for content and preparation of the manual. The airworthiness limitations section of the manual, and any revisions thereto, must be FAA/AUTHORITY approved. The “continued airworthiness” sections which contain the manufacturer’s recommendations for continued airworthiness are not FAA/AUTHORITY approved.

(ii) The airworthiness limitations section contains information derived primarily but not solely from the data approved under § 29.571. Approval of this section of the manual must be completed before type certification. See Part 29, Appendix A, paragraph A29.4 of Amendment 29-20. (For further information, see the comments for Proposal 8-25, § XX.4 in the preamble of Amendment 29-20 (45 FR 60154, September 11, 1980)).

(iii) Part 29, Appendix A, paragraphs A29.3(a) and (b) pertain to the content of the instructions for continued airworthiness. For example, scheduling,

overhauls (including recommended overhaul periods or TBO), inspections, and servicing information are included in this section of the manual.

(2) Identifying and Serializing Fatigue Critical Components.

(i) Part numbers and serial numbers must be applied to fatigue life limited components as noted in §§ 45.14 and 29.1529(a)(1) and (2) of Amendment 29-4. Electric arc marking methods should not be used due to possible internal arcing, pitting of surfaces, and changes in physical or chemical characteristics due to the local high temperature at the arcs.

(ii) Vibrating pencils, name plates, or permanent inks may be used. However, serial numbers should be applied on each part such that material is upset or displaced on the part, thereby attaining a more permanent number. This is not a requirement however. When material is upset or displaced, the least critical or lowest stressed area should be used.

(iii) For small parts, the rule (§ 45.14) allows markings that are equivalent to part and serial numbers. Markings or symbols may be used to enable the identification of a part as one for which a replacement time, inspection interval, or related procedure is specified in the airworthiness limitations section. The FAA/AUTHORITY-stated identification of such small parts is clearly essential for safety and may not be relieved. With adoption of Amendment 29-20, the marking requirements that were contained in § 29.1529 are now contained in § 45.14, Amendment 45-12.

(3) The FAA/AUTHORITY inspector should witness the rigging of the controls of a test rotorcraft. This is imperative for a new rotorcraft design to ensure the practicality and feasibility of the procedures stated in the design data and/or the maintenance manual. The type design data information should be used, and the FAA/AUTHORITY should ensure the manual includes the proper information. Rigging procedures are not included in the airworthiness limitations section.

(4) As a recommendation, a draft copy of the manual should be available to the FAA/AUTHORITY for use during the F&R program if such a program is conducted under § 21.35(b). The manual must be completed and furnished with each aircraft receiving an airworthiness certificate, § 21.50(a) and (b).

(i) For rotorcraft certified to § 29.1529(a)(2) of Amendment 29-4, changes to the airworthiness limitations shall be furnished on request. See § 21.50(a).

(ii) For rotorcraft certified to § 29.1529 of Amendment 29-20, changes to the manual shall be made available to those that need the manual. See § 21.50(b).

(5) Service experience may dictate additional and subsequent (to type certification) changes to the airworthiness limitations section. AD’s may be used to

revise the limitations. (The relationship between AD's and the process of changing these limitations is covered in the preamble of Amendment 29-4 (33 FR 14104; September 18, 1968.) Whenever the revised limitations are made restrictive for aircraft in service, the Administrative Procedures Act requires "notice and public procedure" to persons that may be affected and to satisfy the requirement for notification of the changes and identification of the correct issue of the airworthiness limitations, if appropriate. This procedure is also used for restrictive or reduced operation limitations in the RFM.

(6) FAA Order 8620.2, November 2, 1978, Applicability and Enforcement of Manufacturers Data, may be reviewed for further information. This does not reflect the rule changes made in October 1980 but applies to prior standards.

AC 29.1529A. § 29.1529 (Amendment 29-26) INSTRUCTIONS FOR CONTINUED AIRWORTHINESS (MAINTENANCE MANUAL).

a. Explanation. Amendment 91-21, 54 FR 41211, October 5, 1989, recodified certain paragraphs in FAR Part 91. This revision corrects a reference from FAR § 91.163 to FAR § 91.403.

b. Procedures. Correct the references in paragraph AC 29.1529a(1) from §§ 43.15, 43.16, and 91.163(c) to §§ 43.15, 43.16, and 91.403 of the operating rules.

SUBPART G - OPERATING LIMITATIONS AND INFORMATION

MARKINGS AND PLACARDS

AC 29.1541. § 29.1541 MARKINGS AND PLACARDS - GENERAL. (SEE PARAGRAPH AC 29.1543).

AC 29.1543 (AC's 29.1541, 29.1545, & 29.1549). Sections 29.1541, 29.1543, 29.1545, and 29.1549 (Amendment 29-26) INSTRUMENT MARKINGS GENERAL

a. Background and Explanation.

(1) Aircraft instruments have historically been marked in a variety of ways and with an interesting assortment of symbols. During this period, a limited number of regulatory requirements have been incorporated in the FAR 29, Subpart G, “Markings and Placards,” and these efforts have standardized some basic aspects of instrument marking for rotorcraft. As rotorcraft have become increasingly complex with increased number of engines, one-engine inoperative ratings, more sophisticated instrumentation, etc., the need for more specific standards has greatly increased.

(2) It is vitally important that instrument markings be standardized among rotorcraft. When markings are not standardized, considerable confusion and additional workload may be introduced into the cockpit environment. If markings are not standard, it is conceivable that a marking in one rotorcraft could mean the opposite of a similar marking in another rotorcraft. The results of such a situation could be disastrous when pilots fly several rotorcraft models, and particularly in transport rotorcraft under 12,500 pounds, which do not require a pilot type rating.

(3) The following guidance is offered for the purpose of obtaining a general standardization of instrument markings. It is realized that there are a great many variations in instrument presentations for which all guidance may not apply. This is particularly true of new designs, such as cathode ray tube (CRT) displays currently being presented. It is of overriding importance that the philosophies included here be administered, even if specific guidance cannot be applied for particular designs. Instrument markings are provided to aid interpretation of instruments quickly and accurately. Good instrument markings should indicate operating conditions at a glance. The best markings are ordinarily the simplest markings.

b. Procedures.

(1) Limits. Each maximum allowable limit substantiated for safe operation must be marked with a red line. This marking should be a red radial line for circular gages. If there is a minimum allowable limit for safe operation, this value should also be marked with a red (radial) line. The use of multiple red (radial) lines should be avoided except where their use is readily usable by the pilot. Normally, no more than one maximum and one minimum red radial line should be incorporated on any one

instrument to minimize confusion and avoid potential aircrew errors; however, use of multiple red radial lines may be permitted if such marking can be presented in an acceptable manner.

(2) Normal Operating Range. Each normal operating range should be marked with a green arc or green line which does not extend beyond the maximum and minimum values for continuous safe operation. Discontinuities in width have been used when normal ranges vary with other parameters. Integrating instruments in place of these markings should be encouraged although there may be no regulatory requirement for them.

(3) Cautionary Ranges. Time limited ranges, precautionary ranges, or ranges for which special operating procedures are required should be marked with a yellow arc or yellow line. If a yellow range is used to indicate a special operating procedure, information describing the special procedure should be included in the Rotorcraft Flight Manual.

(4) One-Engine-Inoperative Markings. One-engine-inoperative (OEI) ratings represent a special challenge for retaining simplicity and clarity in powerplant instrument markings. OEI ratings are eligible to be used only during an extremely small portion of total flight time; therefore, they should not dominate the presentation or obscure other markings. They are needed only for reference. Indices for 2½-minute and 30-minute power may be marked above the takeoff power redline on engine power instruments. OEI reference markings should be clearly distinct from the normal all-engines operating markings. One acceptable means of marking OEI limits has been narrow dashed radials with yellow for 30-minute, and red for 2½-minute limits. OEI markings should be consistent between gages. For example, a 30-minute marking on an N_1 or torque gage should be similar in appearance to the 30-minute marking on the engine temperature gage.

(5) Red Arcs or Ranges. Sections 29.1549(d) and 29.1553 allow the use of red arcs. Experience has proven that when red arcs are used to indicate maximum or minimum values, the meaning of a red line loses its significance. Therefore, the use of red ranges or arcs to indicate limit values should be discouraged. Red is conventionally used to represent a limit (maximum or minimum) for which an aircraft or component has been substantiated. A “range” of limits for a given parameter is not consistent with the definition of the terms “limit,” “minimum,” or “maximum.” In addition, a red arc tends to imply that more than one value is limiting, that a scale is provided to show operation within a range of values, and that an absolute limit may not exist until the extreme of a red range is attained. These implications must be avoided wherever possible by specifying a single limiting value and marking it with a single red line (radial). If readings in excess of that value were indicated, it would then be obvious to the crew that a limit had been exceeded. A red arc may be used to indicate a transient vibration range as indicated in § 29.1549(d); however, if the range is a cautionary range and not a prohibited range, use of a yellow arc is recommended. The fuel gage configuration described in § 29.1553 is considered a special application of red arcs. Occasionally a

red arc has been utilized when limits vary with other parameters. Discontinuities in width could conceivably represent limits when other parameters are considered. The use of integrating instruments would alleviate much of the problem and should be encouraged although it is recognized that there may be no regulatory requirement for them.

(6) Flight Evaluation. In evaluating gage markings, the final criterion must be, "Are the markings adequate for correct interpretation by the crew?" FAA/AUTHORITY evaluations of gage markings should begin early in a certification program utilizing a cockpit or aircraft mock-up whenever possible. All required gages and gage markings must be readable from each pilot station. Depending on cockpit and window geometry, gages should be evaluated in direct sunlight unless they are located high on the panel underneath a substantial glare shield. Evaluation in direct sunlight is especially important for any displays using light bars of digital lighting segments, such as digital radar altimeter presentations or vertical scale instruments using light segments. Required gages must be readable without upper body movement or extensive head movement by the crew. Evaluators should be especially alert to any scale markings or range markings which are obscured by parallax, as such features are unacceptable. If the aircraft is to be approved for night operation, each required indicator must also be evaluated during night lighting conditions. The same visibility requirements apply for night; however, the evaluator should particularly look for lighting features which may change or obscure the colored markings. For example, in one case, red gage markings were totally obscured by red instrument lighting. Except for minor changes, lighting should be evaluated in flight in order to correctly evaluate vibration effects and various background lighting conditions.

(7) Digital Instruments.

(i) For purposes of this discussion, two types of digital indicator are considered: (1) an indicator which consists of a column of light segments which illuminate sequentially to display changing values, and (2) an indicator which consists of horizontal and vertical line segments in the configuration of a block "8" to display numerical values. Both indicator types work well for parameters where trend information is generally not needed such as engine oil pressure or temperature. However, for rapidly changing parameters such as engine exhaust gas temperature, torque, or RPM, trend information may not be attainable. Advisory Circular 20-88 (guidelines on the marking of power plant instruments) specifies that instrument markings are intended to provide necessary information at a glance. Trend information for power indicators is vitally important for safe operation of a rotorcraft, and this information must be obtainable at a glance. For the columnar light segments, the ability to quickly detect trend information is largely a function of the resolution provided by single segments (e.g.; if there are two segments for each percent RPM, the ability to detect trend information is better than if there is only one segment for each percent RPM). For digital indicators displaying numerical values, trend information may be unattainable because rapidly changing parameters produce a blur, and this design may be unsuitable as a single source of information. The evaluator should use a great deal

of caution to assure adequate trend information is available in primary power and rotor indicators of digital design.

(ii) Another area of concern in digital and moving tape instruments is the ability to determine when limits are being approached. Color code markings are frequently incorporated on the moving face of a tape or digital presentation. In such cases, it is mandatory that limit markings be affixed adjacent to the presentation, or that another means be provided so that the pilot can anticipate approaching a limit. The beginning and end of normal and cautionary ranges should be marked adjacent to the display. The entire range need not be color coded adjacent to the display if the colors are integral on the face of the tape or in the individual digital segments. Marking of limit values solely on the tape or in the colored light segments alone is unsatisfactory. Marking of digital indicators displaying numerical values is adequately addressed in AC 20-88, paragraph 3, General.

(iii) Appropriate failure modes should be evaluated during the system analysis. This will ordinarily include portions of the digital display. Such failures should be detectable whenever they affect reading accuracy. As a result of this analysis, the system may incorporate a test feature which assures all digital segments operate satisfactorily. This feature should be encouraged.

(8) Additional Markings. To keep markings standardized and uncomplicated, only the FAA/AUTHORITY-approved ranges and limits should be included. Items such as manufacturer's recommended values or manufacturer's warranty information are inappropriate for instrument markings and should not be included. Such information may be presented elsewhere. Transient limits may be indicated by a small red index such as a dot or triangle. Information defining allowable conditions for each transient index should be in the rotorcraft flight manual (e.g., maximum for starting, 12 seconds).

(9) Airspeed Indicator. While the foregoing information is generally applicable to airspeed indicators, some particular features warrant additional attention.

(i) A red cross-hatched radial line should be located at power-off V_{NE} if that value is less than power-on V_{NE}.

(ii) Many rotorcraft have erratic, unreliable, or nonrepeatable airspeed indications at low speed which warrant caution when operating in that speed range. In such cases, a yellow arc on the instrument with appropriate flight manual explanation has been found acceptable.

(iii) Indicated airspeed values should be utilized for all airspeed indicator markings.

(iv) Airspeed "bugs" may be used to highlight important takeoff, landing, or limit speeds. This concept may generally be encouraged; however, there are a maximum number of "bugs" that can be utilized without confusion for any given

indicator. Typically, two “bugs” are acceptable; three or more are questionable. “Bugs” may also be used on a variety of instruments other than the airspeed indicator.

(10) Additional Reference Material. Additional procedures for marking powerplant instruments are contained in Advisory Circular 20-88. Where conflicts for rotorcraft exist between AC 20-88 and this document, the more recently dated publication should be utilized.

AC 29.1545. § 29.1545 (Amendment 29-17) AIRSPEED INDICATOR. (SEE PARAGRAPH AC 29.1543).

AC 29.1547. § 29.1547 MAGNETIC DIRECTION INDICATOR.

a. Explanation. This regulation identifies the requirement for a calibration placard for the magnetic direction indicator and where it should be located.

b. Procedures. One means of accomplishing the requirements of this regulation is commonly known as swinging the compass. A surveyed compass rose is laid out on an appropriate surface. The compass rose location should be free from the influence of steel structures, underground pipes and cables, reinforced concrete, and other aircraft. The aircraft should be in an attitude which permits an accurate result. Normally the engines are in operation; however, if the rotorcraft is equipped with an auxiliary power unit which can supply all required electrical power, this can be used in lieu of engine driven generators. Turn the aircraft on successive headings through 360°. It is recommended that the increments be every 30°; however, the increments should not exceed 45°. Prepare a placard to show the correction to be applied at each of the selected headings. When significant errors are introduced by operation of electrical/electronics equipment or systems, the placard should also be marked at each calibration heading showing the correction to be applied when such equipment or systems are turned on or energized. The placard resulting from this calibration should be installed on or near the magnetic direction indicator.

AC 29.1549. § 29.1549 (Amendment 29-34) POWERPLANT INSTRUMENTS.

a. Explanation. Amendment 29-34 introduces the optional ratings of 30-second/2-minute OEI. Section 29.1549(e) has been revised to show that the limits for the 30-second OEI rating are not required to be marked. Use of the 30-second OEI rating is limited to critical phases of operation after a failure or precautionary shutdown of an engine. During this critical stage of operation the crew should not be required to monitor engine instruments to avoid exceedances. Automatic control of the 30-second OEI limits are required by Section 29.1143(e), therefore the 30-second OEI limits are not required to be marked.

b. Procedures. The method of compliance is unchanged except the marking of 30-second OEI limits is unnecessary.

AC 29.1551. § 29.1551 OIL QUANTITY INDICATORS.

a. Background. This section states that each oil quantity indicator must be marked with enough increments to indicate oil quantity readily and accurately.

b. Procedures. There are several different ways in which the oil quantity indicator may be presented. Some of the ones more prevalent in the industry are:

(1) Oil quantity indicator. (Generally used when large amounts of reserve oil are required.)

(2) Oil quantity dip stick. (Most common method of measuring engine oil.)

(3) Oil quantity sight indicator. (Generally used for measuring transmission and gearbox oil quantities.)

c. No matter what method of oil quantity indicator is used, the indicator should be marked so that the oil quantity can be accurately determined. This can range from increments marked in gallons, such as oil quantity indicators for large amounts of oil, to oil quantity indicators marked in quarts with full and add marks, such as engine dip sticks. Sight indicators with full and add marks have been used successfully for gearboxes. Sight indicators normally do not reflect quantities. These are some of the methods currently in use to indicate the oil quantity. In all cases, those methods identified above have proved to be an acceptable method of showing compliance with § 29.1551.

AC 29.1553. § 29.1553 FUEL QUANTITY INDICATOR.

a. Explanation. This section describes the markings necessary to identify the portion of unusable fuel that cannot be used in level flight. Unusable fuel may be present in a design due to the relative configuration of the fuel tank to the fuel tank outlet (e.g., sumps, unusual elevations and/or configurations dictated by aircraft contours, etc.). If the unusable fuel supply for any tank is less than or equal to 1 gallon or is less than or equal to 5 percent of the tank capacity, whichever is greater, this section does not apply.

b. Procedures. For each fuel tank which has an unusable fuel capacity exceeding 1 gallon or 5 percent of the tank capacity, whichever is greater, the following should be accomplished:

(1) Calibration computations, measurements, and/or tests should determine the zero (empty) position on the fuel quantity indicator (reference § 29.1337).

(2) The lowest reading obtainable in level flight must be determined by computation, measurement, and/or testing.

(3) Once the instrument readings defined by paragraphs b(1) and (2) above have been determined, a red arc should be placed between the readings on the fuel quantity indicator.

(4) Appropriate notations should be made in the flight manual to define the intent of the red arc to the flightcrew (reference § 29.1585(e)).

AC 29.1555. § 29.1555 (Amendment 29-24) CONTROL MARKINGS.

a. Explanation. Section 29.1301(b) requires that all installed equipment be labeled to identify its function and operation. This section provides more detailed requirements for control markings. Specific criteria are given for powerplant fuel controls, fuel quantity markings, and landing gear controls. The requirement to color emergency controls red is in this section.

b. Procedures.

(1) Section 29.1555(a) requires that each cockpit control, other than flight controls whose function is not obvious, must be appropriately labeled. The primary flight controls are the cyclic, collective, and the directional control (tail rotor) pedals. For the control to be appropriately labeled, the rule requires that there should be an obvious and clear demarcation of the function and operation of the control. When performing the evaluation to determine the adequacy of markings, it should be remembered that only those controls which are quite traditional should be judged to be obvious in their operation. An example of this has been the navigation/communication control heads. The more traditional control units had concentric knobs of decreasing size for the selection of frequency. Because this system was so common for such a period of time, the finding was generally made that the function of this control was obvious and thus did not require a specific marking. However, as more current technology digital electronic controls were used, the frequency selectors were judged not to be obvious in their operation, and their function and operation were required to be labeled.

(2) Review design data and available hardware to ensure the powerplant fuel controls are clearly and permanently marked such that:

(i) Selector valve control clearly shows each position for each tank and each crossfeed configuration.

(ii) Tank selection sequences required for safe operation are clearly and permanently marked on or adjacent to the required selector.

(iii) Each control valve is clearly marked to show the position of the controls for each engine on multiengine rotorcraft.

(3) Review design data and available hardware to ensure that usable fuel capacity is clearly marked as follows:

(i) If the fuel system has no selector controls, usable fuel capacity must be shown on the fuel quantity indicator (reference paragraph AC 29.1553).

(ii) If the system has selector controls, the usable fuel capacity at each selector position must be clearly shown near the selector position.

(4) Markings of essential visual position indicators must be obvious and within view of required crewmembers. Landing gear markings normally include indications for down, intermediate/unsafe, and up. Accepted symbology has included arrows for up/down indications, crosshatching for intermediate/unsafe, various combinations of colored lights, and combinations of all of the above. Cockpit presentation is further discussed in paragraph AC 29.729. Emergency controls which should be marked in red include those used for firewall/emergency fuel shutoff, landing gear blowdown/emergency release, fire extinguishers, float activation, cargo hook release and fuel dump. The method of operation of emergency controls must be clearly marked. In the case of switches and buttons, the method of operation is often inherently obvious without dedicated labeling.

(5) The two most obvious means of displaying landing gear operating speed are use of a placard or an appropriate mark in the airspeed indicator.

AC 29.1557. § 29.1557 (Amendment 29-26) MISCELLANEOUS MARKINGS AND PLACARDS.

a. Explanation.

(1) This section specifies the markings and placards associated with baggage, cargo, ballast, seats, fuel, oil, and emergency exits.

(2) The data contained in these markings and placards must conform to the approved type design of the rotorcraft.

b. Procedure.

(1) The placard for baggage and cargo compartment limitations should clearly state all limitations which apply to that compartment. The limitations may apply to what is carried, the dimensions, exact location, and maximum weight allowed. The placard should be located in a place where it cannot be obstructed and is clearly visible before or after opening the compartment. For ballast, the placard should state the type of ballast permitted (lead plate, shot bags, etc.), the exact placement, if applicable, and the maximum allowable weight. If there are other limitations which are applicable to these compartments, they should be clearly stated.

(2) Seats in rotorcraft are designed to meet vertical descent loads which have been established to insure a certain level of occupant survivability in the event of a hard

landing or crash. To meet these load requirements, 170 pounds was established as the minimum occupant design weight. If the seat was designed and certified to an occupant weight lower than 170 pounds, the seat must carry a placard in a conspicuous place, which limits the weight of the seat occupant to the certified weight.

(3) The fuel and oil filler opening markings are self-explanatory.

(4) Emergency exit placards must be so distinctive and clear that they are easily identified and understood under extreme and intense circumstances by individuals who have little or no familiarity with aircraft escape procedures.

AC 29.1559. § 29.1559 (Amendment 29-24) LIMITATIONS PLACARD.

a. Explanation.

(1) The content and location requirements on the placard are specified in the standard. The content and information in the placard has changed significantly as a result of associated and complementary changes in the airworthiness rules and the maintenance and operating rules.

(2) By adoption of FAR Part 29 in 1965, the standard (and its predecessor CAR Part 7) required compliance with the operating limitations in the approved Rotorcraft Flight Manual.

(3) With the adoption of an Airworthiness Limitations Section for the maintenance manual as stated in § 29.1529 of Amendment 29-4, the content of the placard was changed significantly to require compliance with the requirements in that section.

(4) Amendment 29-20, issued in 1980, adopted standards requiring "Instructions for Continued Airworthiness" (maintenance manual). This manual may include an Airworthiness Limitations section which is segregated and an approved part of the manual. The maintenance and operating rules, §§ 43.16, 91.163(c), and other operating rules require compliance with the Airworthiness Limitations Section. Other airworthiness standards were adopted for airplanes, engines, and propellers to similarly require Instructions for Continued Airworthiness and an Airworthiness Limitations Section. See paragraph AC 29.1529 for further information. The limitations placard standard was not changed by this amendment.

(5) Amendment 29-24 adopted a significant change for the placard. The placard must be in clear view of the pilot and must provide a convenient cockpit presentation of the approved types of operation for each aircraft. Other operating and maintenance rules referenced in the previous paragraph provided the basis for much of the change in the placard content.

b. Procedures.

(1) A placard (or durable decal) must be legible to the pilot and located in clear view of the pilot. If two pilots are required, a single placard may satisfy the standard. This aspect will be evaluated by a test pilot. The type inspection report (TIR) should contain a compliance check entry.

(2) The placard must specify the kinds of operations such as VFR, IFR, day, night, or icing for which the particular rotorcraft is equipped and approved if Amendment 29-24 applies.

(3) The placard content for older designs is related to the rotorcraft certification basis. If the rotorcraft type design has an "FAA/AUTHORITY-approved" and segregated Airworthiness Limitations Section of the maintenance manual, the limitations placard may be revised to comply with the new standard. The certification basis should be changed in conjunction with the placard change.

AC 29.1561. § 29.1561 SAFETY EQUIPMENT.

a. Explanation. This standard requires an identification or location marking for each item of safety equipment and operating information for crew-operated controls. Markings and placards must be conspicuous and durable per § 29.1541. Both passengers and crew should be able to identify easily and then use the safety equipment. Liferafts are specifically mentioned.

b. Procedures.

(1) Release devices such as levers or latch handles for life rafts and other safety equipment should be plainly marked. The method of operation should be marked also. Stencils, permanent decals, placards, or other permanent labels or instructions may be used.

(2) Lockers, compartments, or pouches used to contain safety equipment such as life vests, etc., should be marked to identify the equipment therein and to also identify, if not obvious, the method or means of getting to or releasing the equipment.

(3) Safety equipment labels and instructions for use or operation should be used as prescribed. Section 29.1555(d)(2) concerns emergency control markings. White letters and red background (or reverse) shall be used. Section 29.1541 concerns markings also.

(4) Locating signs for safety equipment should be legible in daylight from the furthest seated point in the cabin or recognizable from a distance equal to the width of the cabin. Letters, 1 inch high, should be acceptable. Operating instructions should be legible from a distance of 30 inches. These are recommendations based on § 29.811(b) and (e)(1).

(5) As prescribed, each liferaft must have operating instructions.

(6) Easily recognized or identified and easily accessible safety equipment located in view of the occupants may not require locating signs, stencils, or decals. However, operating instructions are required. A passenger compartment fire extinguisher that is in view of the passengers is an example.

AC 29.1565. § 29.1565 (Amendment 29-3) TAIL ROTOR.

a. Explanation.

(1) This standard concerns tail rotor disc visibility in normal daylight ground conditions. Amendment 29-3 added “daylight” to the standard. A personnel guard is not required. The tail rotor shall be marked to achieve a conspicuous disc whenever the blades are rotating.

(2) Completely shrouded or protected blades may not require contrasting color segments if the shroud provides equivalent protection for personnel on the ground. A simple tubular guard does not alleviate this standard.

b. Procedures.

(1) Each tail rotor blade may be marked with contrasting colors.

(2) During FAA/AUTHORITY compliance inspections or during the flight test program, the tail rotor will be evaluated, qualitatively, in daylight for a conspicuous disc.

(3) As an aid to select proper colors for conspicuousness, see AC 20-47, Exterior Colored Band around Exits on Transport Airplanes. This AC concerns, in part, methods for measuring reflectance (3:1 factor) and contrast colors for transport aircraft. Section 29.811(f)(2) requires contrast colors for exit markings. The AC also contains suggestions for chromatic contrast. A 3:1 reflectance factor between rotor blade segment colors is acceptable. It is recommended that a few combinations of colors be approved to provide a selection of color combinations. The type design drawings will include the necessary information and data for design control.

(4) As a further aid for compliance AC 91-42D, Hazards of Rotating Propeller and Helicopter Rotor Blades, dated March 3, 1983, should be reviewed. Revision D updates statistical information on propeller and rotor-to-person accidents and offers suggestions to reduce the frequency of such accidents. This AC, in part, refers to FAA Report FAA-AM-78-29, Conspicuity Assessment of Selected Propeller and Tail Rotor Paint Schemes, dated August 1978. The report’s abstract states, in part, for two tail rotor designs, a black and white asymmetrical stripe scheme was chosen as “more conspicuous” than a red, white, and black design.

SUBPART G - OPERATING LIMITATIONS AND INFORMATION

ROTORCRAFT FLIGHT MANUAL

AC 29.1581. § 29.1581 (Amendment 29-15) ROTORCRAFT FLIGHT MANUAL - GENERAL.

a. Explanation.

(1) The primary purpose of the Rotorcraft Flight Manual (RFM) is to provide an authoritative source of information considered to be necessary for or likely to promote safe operation of the rotorcraft.

(2) Since the flightcrew is most directly concerned with operation of the rotorcraft, the language and presentation of the flight manual shall be directed principally to the needs and convenience of the flightcrew, but should not ignore the needs of other contributors to safe operation. As used with respect to the RFM, safe operation is construed to include, but not be limited to, operation of the rotorcraft in the manner that is mandatory for, or recommended for, compliance with applicable airworthiness requirements, and with the particular provisions of the operating regulations relating to the rotorcraft's approved performance capabilities.

(3) To serve its intended purpose, therefore, the RFM must include the certificate limitations established for the design as a consequence to the type certification evaluation, the performance information necessary to establish the operating limitations imposed in accordance with appropriate operating regulations, and the procedures and other information necessary to enable the flightcrew to safely operate the rotorcraft within the envelope of limitations thus delineated. The outline presented in this circular is directed toward those objectives.

(4) Information and data that are mandatory for an acceptable RFM are prescribed in §§ 29.1581 through 29.1589, and nothing contained in these sections should be construed as amending those requirements. Certain additional elements of flight manuals, however, have been shown by experience to be practical necessities if the document is to serve effectively its intended purpose.

b. Procedures.

(1) The following criteria do not affect the status of RFMs which are presently approved. When such manuals are amended in the future, however, it is recommended that the concepts of this section be incorporated wherever uniformity or clarity will result.

(2) Only the material required by FAR Part 29, or that considered necessary to implement the operating regulation, should be included in the portion of the manual that is approved by the FAA/AUTHORITY. However, the manufacturer or operator may

include other “unapproved” data in a separate and distinctively identified portion within the same document.

The RFM is considered necessary for safe operation of the rotorcraft and care should be taken to produce a manual that is consistent with the need for completeness and clarity of the required information. Also, since the RFM is necessary for operation of the rotorcraft in accordance with the certificate limitations, it is considered to be public information.

(3) The page size for the RFM will be left to the discretion of the manufacturer. In this regard, operational compliance with § 91.31 should be considered. A cover should be provided and should indicate the nature of the contents by means of the title, “RFM.” Each page of the approved portion should bear the notation “FAA/AUTHORITY approved,” an induction of the approval sequence of that particular page (e.g., a date of approval, a revision number suitably supported by an amendment log which contains the appropriate date, etc.), the rotorcraft model number as it appears on the type data sheet, and any appropriate document identification number. Pages of the unapproved portion of the flight manual would use the issue date in lieu of the FAA/AUTHORITY approved date. The material should be bound in semipermanent fashion so that the pages will be protected and retained in proper sequence. In selecting the form of binding, consideration should be given to the necessity for amendment and the ease with which amendments can be accomplished.

(4) Amendments may take the form of revisions or supplements.

(i) A revision is a change to the RFM or its supplement made by the holder of the applicable type certificate (TC) or in the case of supplement prepared as a part of a supplemental type certificate (STC), by the holder of the STC.

(ii) A supplement is an addition to the RFM. If the rotorcraft manufacturer (holder of the TC) adds optional equipment or specific operations (such as Category ”A” vertical operation or IFR operations), then the rotorcraft manufacturer is responsible for preparing any necessary flight manual material whether he elects it to be a supplement or a revision to the basic manual. If someone other than the rotorcraft manufacturer applies for an STC to install equipment or modify the rotorcraft such that a RFM supplement is necessary, then the person who applies for the STC is responsible for the preparation of the RFM supplement.

(5) “Revision” may be incorporated by inserting new pages which embody the amended text and, where applicable, by removing superseded pages. A vertical amendment bar should be inserted in the outer margin, where practicable, to indicate those parts of the text that have been changed. Each amended page should be identified in the same manner as pages of the basic manual, and in addition should carry an identification of its approval sequence.

(6) Supplements are incorporated in the manual by inserting the applicable pages which contain the information associated with the particular change. Each supplemental page should also identify the rotorcraft type and model flight manual for which the supplement was issued, the name of the issuer, and the FAA/AUTHORITY approval date. The following statement is an example of a note which would be included on the title page of a flight manual supplement: "For rotorcraft approved to operate in accordance with the provisions of the rotorcraft flight manual supplement, the information contained herein supplements the information of the basic flight manual. For limitations, procedures, and performance data not contained in this supplement, consult the basic flight manual."

(7) Supplements should contain as much of the flight manual contents outlined below as considered appropriate for the particular change in type design, including title page and index of contents. It is suggested that these be prepared with a view to insertion in the FAA/AUTHORITY-approved portion of the flight manual as a complete and self-contained unit.

(8) The RFM should contain as much of the information required in Part 29 as is applicable to the individual type and model. For the purpose of standardization, it is recommended that the sequence of sections and of items within sections, follow the format presented at the end of this paragraph if practicable.

(9) The following information would normally be included in the introduction section of the flight manual.

(i) Title Page. This page should include the manufacturer's name and address and the rotorcraft model number as it appears on the type certificate data sheet. If desired, include a trade name or trade model number in quotes, provisions for rotorcraft serial number and registration number, approval date of the basic document, and title and signature of the FAA/AUTHORITY approving official.

(ii) Table of Contents. An index should be located at the front of each section or at the front part of the manual.

(iii) Amendment Log. This log should be in the form of a table with provisions to record, for each amendment, an identifying number, title or description, the page numbers involved, the issue date, the identification of the FAA/AUTHORITY approving official, and the FAA/AUTHORITY approval date.

(iv) Separate amendment logs should be provided for each type of amendment issued; i.e., Log of Revisions, Log of Supplements, etc. Amendments issued by other than the holder of the basic type certificate should include a separate amendment log which, in addition to the issue date, should also identify the issuer and the STC number or other approval basis for the associated modification.

(v) List of Current Pages. This table should list, for each approved page of the manual, the issue date and any other appropriate identification necessary to establish that the manual is complete and current.

(10) The following flight manual format would be acceptable. The format recommends a sequence of sections and suggests items which would be included in those sections.

FLIGHT MANUAL FORMAT

INTRODUCTION

PART I, FAA/AUTHORITY APPROVED

Section 1 Limitations

Section 2 Normal Procedures

Section 3 Emergency Malfunction Procedures

Section 4 Performance Data

Section 5 Optional Equipment Supplements

PART II, MANUFACTURER'S DATA

Section 6 Weight and Balance

Section 7 Systems Description

Section 8 Handling, Servicing, and Maintenance

Section 9 Supplemental Performance Information

INTRODUCTION: This section would include any signature pages, list of approved pages, the log of revisions, and any additional introductory information desired. For each section, it is suggested that the following major titles be utilized and that the recommended information listed under each title be incorporated. Each section should include a table of contents and a list of figures applicable to that particular section.

Section 1 - Limitations:

a. Kinds of Operation.

Under this heading, crew requirements, VFR and/or IFR flight authorizations, and any operational restrictions would be presented.

b. Flight Limitations.

This section would include limitations with respect to airspeed, altitude, ambient temperatures, wind, slope, prohibited maneuvers, and any other flight limitations associated with a particular rotorcraft (i.e., HV limitations for Part 29 Category A rotorcraft).

c. Weight Limitations.

This section would contain all gross weight, center of gravity (both longitudinal and lateral) limitations, and any other weight limitations unique to the rotorcraft (i.e., crew, passenger and/or cargo loadings, WAT limitations for Part 29 rotorcraft, etc.).

d. Powerplant Limitations.

This section would include the temperature and pressure limits associated with powerplant operation; i.e., torque, RPM, turbine outlet temperature (TOT), etc. This section would also include approved fuels and oils and their temperature and pressure limits. Any accessories attached to the powerplant (i.e., starters, generators, etc.), to which limitations in starting or operation are applicable, would be included herein.

e. Rotor Limitations.

This would include the power-on and power-off RPM limits, the effect of altitude on these parameters, and any other limitations associated with the rotor system(s).

f. Drive System Limitations.

This section would include all limitations associated with the drive system (i.e., main transmission, any adapter gear boxes, tail rotor gearbox, and any other drive system component applicable to a particular rotorcraft).

g. System Limitations.

This section would include any particular system limitations unique to the rotorcraft (i.e., battery limitations, hydraulic system limitations, and any limitations associated with the various types of stability augmentation and/or automatic flight control systems).

h. Instrument Markings.

All instrument markings would appear in this section. The significance of each limitation and of the color coding would be explained in this paragraph.

i. Placards.

The exact wording and general location of all placards pertaining to flightcrew function or cargo loading would appear in this section.

Section 2 - Normal Procedures:

a. Preflight Checks.

This paragraph would include any exterior, interior, and any system checks prior to starting the engine(s).

b. Engine Start.

This paragraph would include any procedures associated with the engine start(s).

c. System Checks.

This paragraph would include any system check procedures such as hydraulic, stability augmentation, electrical, flight control, etc., which should be accomplished prior to takeoff.

d. Takeoff.

This paragraph would include any procedures associated with the takeoff and any procedures unique or applicable to the takeoff profile.

e. Cruise and/or Level Flight.

This paragraph would include any procedures applicable to cruise and/or level flight operation.

f. Approach and Landing.

This paragraph would include any procedures required or recommended for the approach and landing duration of the rotorcraft operation.

g. Engine/Rotor Shutdown.

This paragraph would include any procedures applicable to the engine and/or rotor shutdown and any procedures applicable upon completion of the rotorcraft operation.

h. Miscellaneous Procedures.

This section would include procedures for miscellaneous systems or conditions, such as bleed air heater, anti-ice systems, cold weather operations, etc.

Section 3 - Emergency and Malfunction Procedures:

a. Introduction.

This paragraph would include any introductory type information (i.e., definitions of terms used and any other information the manufacturer deemed appropriate).

b. Powerplant Failures.

This paragraph would include any information relative to engine, fuel control, or any other powerplant related emergency or malfunction.

c. Drive System Failures.

This paragraph would include recommendations and procedures relative to any drive system failure and/or malfunction.

d. System Failures.

This paragraph would include procedures and recommendations relative to any system failure and/or malfunction (i.e., electrical, hydraulic, and augmented flight control systems).

e. Fire.

This paragraph would include procedures to be followed in the event that engine, cabin, baggage compartment fire or smoke is detected.

f. Emergency Egress.

This paragraph would include emergency evacuation procedures for both the flightcrew and the passengers.

Section 4 - Performance Data:

a. Power Assurance.

This section would include all information relative to the power assurance checks.

b. Hover Information.

This paragraph would include all information relative to hover performance (i.e., hover ceiling in ground effect (IGE) and out of ground effect (OGE) for single and/or multiengine operation). Any relative wind effects would also be included.

c. Takeoff and Landing and Climb Performance.

This paragraph would include information relative to the takeoff and landing profiles (i.e., height-velocity (HV) curves, normal climbs, autorotation speeds, takeoff and landing distance over 50-foot obstacles, and any other data applicable to the particular rotorcraft).

d. Airspeed Calibration.

This paragraph would include the airspeed calibrations required for the particular rotorcraft.

Section 5 - Optional Equipment Supplements:

This section would include all optional equipment supplements. These supplements may modify any of the limitations, procedures (both normal and emergency), and performance characteristics of the basic rotorcraft.

PART II, Manufacturer's Data (Not FAA/AUTHORITY Approved)

Section 6 - Weight and Balance:

All supplemental weight and balance information such as crew tables, passenger tables, fuel and oil tables, cargo tables, and any other loading tables applicable to the particular rotorcraft would appear in this section.

Section 7 - Systems Description:

This section would include all information relative to the various rotorcraft systems that the manufacturer believes would apply to the particular rotorcraft.

Section 8 - Handling, Servicing, and Maintenance:

This section would include all information relative to the handling, servicing, and maintenance that the manufacturer would care to present. This section would also include dimensions (i.e., baggage areas, doors, and any internal, external information appropriate to the rotorcraft).

Section 9 - Supplemental Performance Information:

This section would include any supplemental performance information the manufacturer would wish to provide. This section would also contain the cruise-range information associated with IFR operation.

AC 29.1583. § 29.1583 (Amendment 29-24) OPERATING LIMITATIONS.

a. Explanation. The purpose of this section is to present the limitations applicable to the rotorcraft type and model as established in the course of the type certification process. The limitations should be presented without explanations other than those explanations prescribed in Part 29. To the maximum practicable extent, the limitations should be presented in "operations" language and format. Since operation of the rotorcraft in accordance with such limitations is required by the operating regulations, the following should be inserted as a note at the beginning of this section: "Operation in compliance with the limitations presented in this section is required by the Federal Aviation Regulations." Section 29.1583 merely states that certain information must be given. The specific information is found during the showing of compliance with other paragraphs in the regulation.

b. Procedures.

(1) Section 29.1545 gives the markings required for the airspeed indicator.

(2) Rotor limits are established during compliance with § 29.33. The markings are specified in § 29.1549.

(3) Powerplant limits are discussed under §§ 29.1549 through 29.1553.

(4) Weight limitations are specified in § 29.25. In the operating limitations section, there should be a statement of the maximum and minimum certificated takeoff and landing weights. For those weight limitations that vary with altitude, temperature, or other variables, the variation in weights may be given in the form of graphs in the performance section of the manual and included as a limitation by specific reference in the limitations section to the appropriate graph or page.

(5) Center of gravity (CG) limits are determined in accordance with § 29.27 and may be presented in the same manner as prescribed for the weight limitations (i.e., a statement under "center of gravity limits" in the limitations section which references

graphs or page numbers in the performance section). If landing gear position can measurably affect allowable CG, this information should be presented together with the moment change due to gear retraction.

(6) The minimum flightcrew is determined under § 29.1523 and is dependent upon the kinds of operation authorized. The established number and identity, by crew position of the minimum flightcrew, must be listed.

(7) Kinds of operations are established under § 29.1525. This section should contain the following preamble: "This rotorcraft is certified in the Transport Category (A and/or B) and is eligible for the following kinds of operation when the appropriate instruments and equipment required by the airworthiness and/or operating rules are installed and approved and are in operable condition." Those of the following, and any others that are applicable, should be listed.

(i) Day and night VFR.

(ii) Approved to operate in known icing conditions.

(iii) IFR.

(iv) Category A vertical operations from ground level or elevated heliports.

(v) Extended overwater operations (ditching).

(vi) External load operation.

(8) Limiting heights and speeds are determined in accordance with § 29.79 and established as operating limitations in accordance with § 29.1517.

(i) For transport Category A rotorcraft, § 29.1583(f) requires that enough information be furnished in the limitations section of the RFM to allow compliance with the requirements of § 29.1517. One method of complying with this requirement is to provide charts or graphs similar to those shown in figures AC 29.79-1 and AC 29.79-2 as required to encompass the approved takeoff and landing envelope of the rotorcraft. However, many Category A approvals have not required an actual HV diagram to be included in the RFM for Category A operations. The Category A takeoff and landing profiles are developed so that a continued takeoff, go-around, or safe landing can be accomplished following failure of the critical engine at any point in the profile. Development of the Category A profiles is very similar to HV testing. The resulting takeoff and landing profiles coupled with precisely defined procedures and the weight, altitude, and temperature (WAT) limitations for which the profiles have been shown to be valid constitute an operating envelope for which compliance with § 29.1517 has been demonstrated. During the Category A flight test evaluation, abuse testing is done to verify that variations reasonably expected to occur in service will not result in a hazardous condition from which a safe landing cannot be accomplished. Therefore, if

the Category A takeoff and landing profiles, procedures, and WAT limitations are adequately and clearly defined in the RFM, this information is considered sufficient for compliance with the requirements of § 29.1583(f) without the inclusion of an actual HV diagram. The Category A procedures and profile definitions may be presented in the normal procedures or performance sections of the RFM but should be referenced as being mandatory requirements in the limitations section unless an HV diagram valid for Category A operations is presented.

(ii) For transport Category B rotorcraft, the height-speed information developed in accordance with § 29.79 should be included in the performance section of the RFM in accordance with § 29.1587(b)(6). HV diagrams similar to those shown in figures AC 29.79-1 and AC 29.79-2 have been satisfactory for previous certifications.

(iii) For transport Category B rotorcraft with FAR Part 29 and CAR Part 7 certification bases prior to Amendment 29-21, the HV information should be included in the limitations section of the RFM unless the following procedure has been accomplished for rotorcraft which satisfy the following conditions:

(A) Certificated for a maximum gross weight of 20,000 pounds or less; and

(B) Configured with nine passenger seats or less. RFM's for rotorcraft falling in this group may be revised to remove the HV data from the limitations section and place it in the performance section. Such actions should be processed and approved by a supplemental type certificate (STC). Conditions b(8)(iii)(A) and (B) above should be shown as limitations on the STC, and the certification basis should include Amendment 29-21. If a type certificate (TC) holder desires to revise his type design to take advantage of Amendment 29-21, the certification basis on the TC data sheet should be revised to show §§ 29.1, 29.79, 29.1517, and 29.1587 of Amendment 29-21 for the HV data in the RFM. Foreign manufacturers cannot apply for an STC under current FAA policy. Therefore, a TC amendment would be required for any foreign rotorcraft TC holder to take advantage of this regulatory relief.

(9) Unusable fuel tests are required by § 29.959. When the amount of unusable fuel has been determined, the manufacturer calibrates his fuel quantity system so that when the fuel quantity in the tank is down to the unusable quantity, his fuel gage will read "zero." Additional information may also be provided in the RFM to advise the pilot(s) of different unusable fuel quantities for various flight conditions.

(10) Often other limitations are included in the limitations section that are not specifically mentioned in the rules but which are necessary for safe operation. Examples are:

(i) Altitude limits.

(ii) Ambient temperature limits.

(iii) Conditions for use of rotor brake.

(iv) Prohibitions against prolonged hover in cross or tail winds to prevent accumulation of noxious fumes in cockpit or cabin.

(v) Prohibitions against acrobatic maneuvers.

(vi) Required placards including text and location.

(vii) Special airworthiness equipment installations such as engine out or low rotor RPM warning systems.

AC 29.1583A. § 29.1583 (Amendment 29-24) OPERATING LIMITATIONS.

a. Explanation. Amendment 29-24 to the regulation establishes additional operating limitations for maximum allowable wind for operation near the ground and ambient temperature limits.

b. Procedures. All of the previous advisory material remains applicable except that the minimum and maximum ambient temperature limitations are required in the limitations section. (These limitations were optional before Amendment 29-24.) Additionally, the wind envelope for safe operation near the ground, which is established under § 29.143(c), must be included in the Limitations section. Such operations may include: IGE hover, takeoff, landing, rolling takeoff, rolling landing, and taxi. Advisory material for § 29.143(c) is given in paragraph AC 29.143(a)(2)(ii).

AC 29.1585. § 29.1585 (Amendment 29-24) OPERATING PROCEDURES.

a. Explanation. The procedures sections of the manual should contain essential information peculiar to the particular type or model, the knowledge of which may be expected to enhance safety in the kinds of operations for which the type or model is approved. Information or procedures not directly related to airworthiness, or not under control of the crew, should not be included, nor should any procedure which is accepted as basic airmanship.

(1) Procedures information should be presented with respect to normal and emergency procedures. Alternatively, information outside the category of normal procedures may be subdivided into categories described as “abnormal” procedures and “emergency” procedures, as described herein.

(2) Notes, cautions, and warnings may be used to emphasize specific instructions or information in general accord with the following.

(i) "Note" should be used with respect to matters not directly related to safety but which are particularly important (e.g., Note: For normal twin-engine operation, maximum permissible torque needle split is 4 percent total).

(ii) "Caution" should be used with respect to safety matters of a secondary order not immediately imminent (e.g., Caution: On engine restart reduce inter-turbine temperature (ITT) to 750° C on the operating engine).

(iii) "Warning" should be used with respect to safety matters of a primary order or imminent (e.g., Warning: Do not allow rotor RPM to drop below minimum limits).

(3) The operating procedures of this section have been developed with specific regard for the design features and operating characteristics of the rotorcraft and have been approved by FAA/AUTHORITY for guidance in identifying acceptable procedures for safe operation. Observance of these procedures is not mandatory, and FAA/AUTHORITY approval of such procedures is not intended to prohibit or discourage development and use of improved or equivalent alternate procedures based on operational experience with the rotorcraft. When alternate procedures are used, full responsibility for compliance with applicable airworthiness safety standards rests with the operator.

b. Procedures. Procedural information should be presented in substantial accord with the categories described below:

(1) Normal Procedures. Normal procedures are concerned with peculiarities of the rotorcraft design and operating features encountered in connection with routine operations, including malfunction cases not considered in the other procedures section (i.e., not considered to degrade safety). Material conforming to the above should be presented for each phase of flight, following in sequence from preflight through engine shutdown, and should include, but not be limited to, systems operation (including fuel system information prescribed in § 29.1585(b)), missed approaches, etc.

(2) Abnormal Procedures (Optional). Abnormal procedures are concerned with foreseeable situations, usually entailing a failure condition, in which the use of special systems, and/or the alternate use of regular systems, may be expected to maintain an acceptable level of airworthiness. Typical examples of events considered to entail abnormal procedures are minor engine malfunctions and associated conditions for safe flight, stopping and restarting engines in flight, extending landing gear or flaps by alternate means, approach with inoperative engine(s), etc.

(3) Emergency Procedures. Emergency procedures are concerned with foreseeable but unusual situations in which immediate and precise action by the crew, as detailed in the recommended procedures, may be expected to reduce substantially the risk of disaster. Typical examples of incidents considered to be emergencies are fire, ditching, loss of tail rotor thrust, etc.

(4) Ditching Procedures. Amendment 29-12 added ditching standards to Part 29. When ditching approval is requested, appropriate procedures and information will be included in the manual. Scale model tests are generally used to prove autorotation “ditching” characteristics and to prove stability in the water (capsize threshold) of the rotorcraft type design. Many rotorcraft designs require emergency float bags that deploy either before water contact or shortly after water contact to provide the flotation and stability necessary to comply with the requirements.

(i) Autorotation altitudes and airspeeds and water contact information, if appropriate, derived from or used during the ditching model tests, should be confirmed during FAA/AUTHORITY flight tests and should be included in the manual. Information concerning sea states or wave heights to length ratios, investigated and found satisfactory, may be included in the manual if nonsevere sea states are likely to be exceeded.

(ii) Instructions for deploying life rafts may be needed for certain designs. For example, if life rafts are stowed outside the cabin, special instructions may be necessary.

(5) Evacuation Procedures for Rotorcraft Litter Configurations. Appropriate procedures and minimum crew requirements should be considered and included in the manual or manual supplement, if necessary, to assure timely evacuation.

(6) The use of illustrations to show controls, instruments, explain systems, etc., is encouraged.

AC 29.1587. § 29.1587 (Amendment 29-24) PERFORMANCE INFORMATION.

a. Explanation.

(1) This section should contain the performance information necessary for operation in compliance with applicable performance requirements of Part 29 and applicable special conditions, together with additional information and data essential for implementing pertinent operational requirements.

(2) Performance information and data may be presented for the range of weight, altitude, temperature, and other operational variables stated as operational performance limitations. Performance information which exceeds any operating limitation should be shown only as required for clarity of presentation. If data beyond operating limits are shown, the limits should be clearly marked and the data outside of the limits clearly distinguishable from the data within the limits.

(3) Performance information presented in the unapproved or “manufacturers’ data” section of the RFM should not include performance data that are beyond operating limitations unless the particular operating limit that may be exceeded is

clearly distinguishable from similar performance data that are within limits. For example, if the weight-altitude-temperature (WAT) limits for takeoff and landing are based on in-ground-effect (IGE) hover performance capability at a 5-foot skid height, 3-foot skid height hover performance data allowing increased hovering weights should not be presented in the manufacturers' data unless clearly identified as being beyond operating limitations for normal operations. It is recommended that performance information and data be presented substantially in accordance with the following paragraphs. Where applicable, reference to the appropriate requirement of the certification or operating regulation should be included.

(i) General. Include all descriptive information necessary to identify the configuration and conditions for which the performance data are applicable. Such information may include the complete model designations of rotorcraft and engines, definition of installed rotorcraft features, and equipment that affects performance together with the operative status thereof. This section should also include definitions or terms used in the performance section (i.e., IAS, CAS, ISA, configuration, CDP, V_{TOSS}, Category A, Category B, LDP, etc.) plus calibration data for airspeed, altimeter, ambient air temperature, and other information of a general nature.

(ii) Performance Procedures. The procedures, techniques, and other conditions associated with obtainment of the flight manual performance should be included. The procedures may be presented as a performance subsection or in connection with a particular performance graph. In the latter case, a comprehensive listing of the conditions associated with the particular performance may serve the objective of "procedures" if sufficiently complete. Performance figures are based on the installed minimum specification engine, unless normally depreciated engine performance is approved.

(iii) Wind Accountability. Wind accountability may be utilized for determining takeoff and landing field lengths. This accountability may be up to 100 percent of the minimum wind component along the takeoff or landing path opposite to the direction of takeoff. Wind accountability data presented in the RFM should be labeled "UNFACTORED" (if 100 percent accountability is taken) and should be accompanied by the following note: "Unless otherwise authorized by operating regulations, the pilot is not authorized to credit more than 50 percent of the performance increase resulting from the actual headwind component and must reduce performance by 150 percent of the performance decrement resulting from the actual tail wind component." In some rotorcraft, it may be necessary to discount the beneficial aid to takeoff performance for winds from zero to 10 knots. This should be done if it is evident that the winds from zero to 10 knots have resulted in a significant degradation to the takeoff performance due to flight through the main rotor vortex. Degradation may be determined by determining the power required to fly, by reference to a pace vehicle, at speeds of 10 knots or less.

(iv) The following list is illustrative of the information that should be provided for a transport Category "A" and "B" rotorcraft.

(A) Density altitude chart for converting from pressure to density altitude.

(B) Temperature conversion chart (°C to °F to °C).

(C) Airspeed calibration (calibrated vs. indicated airspeed) for both pilot and copilot systems for level flight, climb, autorotation, and recommended approach rate of descent.

(D) Altimeter correction for pilot and copilot instruments showing the correction factor vs. indicated airspeed at sea level and altitude.

(E) Hover performance charts both in and out-of-ground (OGE) effect with instructions for their use. The OGE hover performance chart is not required but may be useful.

(F) A series of climb performance charts for various weights showing rate of climb vs. pressure altitude for a range of temperatures and showing the variation of best rate of climb speed with pressure altitude. The conditions should appear on each chart (i.e., power, weight, single, or multiengine, etc.). The OEI climb performance charts at 30-minute power and maximum continuous power or at continuous OEI power should provide rate of climb performance down to a minimum of -500 feet/min. The effect of engine air bleed, particle separators or other devices, on the rate of climb/descent performance must be provided.

(G) A chart showing the takeoff flight path for Category A presented in height vs. distance from the hover wheel height to the point at which V_{TOSS} and not less than 35 feet is reached, and the rejected takeoff distance. The chart should identify the critical decision point and V_{TOSS}.

(H) Charts to allow calculation of distance to climb at V_{TOSS} from the point at which V_{TOSS} and not less than 35 feet is reached (or from the lowest point of the takeoff profile for elevated heliport) to 200 feet with one engine inoperative and other engines within approved operating limitations. If conservative, providing charts to allow calculation of the total distance from V_{TOSS} and 35 feet to V_Y and 200 feet is allowed.

(I) A series of charts to allow calculation of any additional distance which may be required to accelerate to best rate of climb speed from V_{TOSS} with one engine inoperative and other engines within approved operating limitations. If conservative, providing charts to allow calculation of the total distance from V_{TOSS} and 35 feet to V_Y and 200 feet is allowed.

(J) Charts to allow calculation of distance to climb at V_Y from 200 feet to 1000 feet above the takeoff surface (or from the lowest point of the takeoff profile for elevated heliport) with one engine inoperative and other engines at 30-minutes OEI

power or maximum continuous OEI power. If conservative, providing charts to allow calculation of the total distance from V_{TOSS} and 35 feet to V_Y and 1000 feet is allowed.

(K) Landing distance chart for Category A showing the landing distance from a 50-foot height (25-foot for VTOL operations from an elevated heliport) to a stop with one engine inoperative vs. pressure altitude over the range of temperatures being certified. This chart should identify the balked landing decision point (LDP) so the pilot will know how to achieve this performance.

(L) For Category B, a series of charts at various weights showing takeoff distance from hover to 50 feet vs. pressure altitude over the range of temperatures being certified.

(M) For Category B, a landing distance chart similar to the one for Category A from a 50-foot height to stop with one engine inoperative.

(N) For turbine-powered rotorcraft in all categories, a power assurance check chart.

(O) For Category B, a statement of the maximum crosswind and downwind components that have been demonstrated as safe for operation near the ground unless this information is incorporated as an operating limitation. (See paragraph AC 29.1583.)

(P) For Category B, the height-velocity (HV) envelope except for rotorcraft which must incorporate the HV diagram as an operating limitation.

(Q) For Category B, the autorotative glide distance as a function of altitude if required by § 29.71. (See paragraph AC 29.71.)

(v) Miscellaneous Performance Data. Any performance information or data not covered in items (A) through (Q) above, but considered necessary to enhance safety or to enable application of the operating regulations, should be included.

AC 29.1587A. § 29.1587 (Amendment 29-40) PERFORMANCE INFORMATION.

a. Explanation. Amendment 29-40 added a requirement to provide the steady gradient of climb for each weight, altitude, and temperature for which Category A performance is presented. No minimum climb gradient has been required.

b. Procedures. No additional flight testing is required beyond that for compliance with the Category A performance requirements. Climb gradient data should be calculated and presented for all weights, altitudes, and temperatures for which takeoff data is scheduled. Gradients should be established for the first and second segment climb under the conditions specified in § 29.67(a)(1) and (a)(2).

AC 29.1589. § 29.1589 LOADING INFORMATION.

a. Explanation. Control of the rotorcraft weight and balance is an operational function, and is the responsibility of the operator. However, instructions necessary to enable loading of the rotorcraft within the established limits of weight and center of gravity, and to maintain the loading within such limits are required by the operating regulations, and inclusion of such loading instructions in the Rotorcraft Flight Manual is required by § 29.1583(c). Approved loading instructions, therefore, must be presented in the Rotorcraft Flight Manual, and at the option of the applicant, may be included in the approved portion or may be included in the unapproved portion.

b. Procedures.

(1) For the purpose of the flight manual, distinction is made here between the loading instructions required by the certification requirements of Part 29, and the weight and balance data required by the operating requirements. The former prescribed information is applicable to the rotorcraft type, and is subject to FAA/AUTHORITY approval as flight manual material.

(2) For compliance with the noted requirements, it is necessary for the applicant to develop weight and balance data and loading instructions as necessary to satisfy the needs of both certification and operation. In order to consolidate in one document information on rotorcraft loading, however, it is recommended that the weight and balance data be developed to include appropriate loading instructions, and that both be included in the Rotorcraft Flight Manual as an “unapproved” section entitled, “Weight and Balance.” Such a section should include the following statement as a note: “In accordance with FAA/AUTHORITY procedures, the detail weight and balance data of this section are not subject to FAA/AUTHORITY approval. The loading instructions of this section, however, have been approved by FAA/AUTHORITY as satisfying all requirements for instructions on loading of the rotorcraft within approved limits of weight and center of gravity, and on maintaining the loading within such limits.”

(3) An actual or specimen weight and balance section should be included in the initial submittal of the manual. Weight and balance data for each particular rotorcraft need not be submitted as flight manual material.

(4) The weight and balance material outlined below is believed to be adequate for rotorcraft with conventional loading and fuel-management techniques. For rotorcraft which necessitate redistribution of fuel (other than normal consumption) to maintain loading within prescribed limits, the material should be amplified as necessary.

(i) Weight Limits. Contained in limitations section of the flight manual.

(ii) Center of Gravity Limits. Contained in the limitations section of the flight manual.

(iii) Dimensions and Datum Line Locations. The dimensions and relative location of rotorcraft features associated with weighing and loading of the rotorcraft and with weight and balance computations should be described and/or illustrated.

(iv) Equipment List. The rotorcraft should be defined or described sufficiently to identify the presence or absence of optional systems, features, or installations that are not readily apparent. In addition, all other items of fixed and removable equipment included in the empty weight should be listed.

(v) Fuel and Other Liquids. Fuel and other liquids, including passenger-service liquids that are included in the empty weight, should be identified and listed together with information necessary to enable ready duplication of the particular condition.

(vi) Weight Computations. Computations of the empty weight and empty-weight CG location should be included.

(vii) Empty Weight and Empty-Weight Center of Gravity Location. Statement of these values should be included.

(viii) Loading Schedule. Loading schedule should be included, if appropriate.

(ix) Loading Instructions. Complete instructions relative to the loading procedure, or to use the loading schedule, must be included.

(x) Special Consideration. Consideration should be given to the lateral center-of-gravity loading instructions when various kits such as a side mounted hoist are installed.